DTN Bundle Protocol on the IETF Standards Track

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Outline

- Delay-Tolerant Networking (DTN)
- The IETF DTN Working Group
- “bpbis” – a revised Bundle Protocol
- BIBE – Bundle-in-Bundle Encapsulation
- bpsec, tcpcl, AMA
- Migration
- Future work

Delay-Tolerant Networking (DTN)

- The Internet is a great system for communication, including command and control ("Internet of Things").
- But it's no good for deep space (and some other cases) because it depends on very brief round-trip times.
- DTN is an automated networking architecture that has the same functions as the Internet but tolerates long round trips.
- Bundle Protocol (BP) is the DTN analogue to the Internet Protocol: a network protocol for difficult networks.
- Reliable "convergence layer" (CL) protocols, such as Licklider Transmission Protocol, running under BP serve the same functions as TCP over IP in the Internet.

The IETF DTN Working Group

- BP is already a standard for space communications, per the Consultative Committee for Space Data Systems (CCSDS).
- But DTN is valuable for some terrestrial applications as well, where link disruption can lengthen round-trip times.
- Widespread integration of DTN into the Internet could solve some networking problems and expand the market for DTN products, reducing cost and risk for space flight deployments.
- In late 2014 the Internet Engineering Task force approved formation of a DTN Working Group, whose first task was to define a revised Bundle Protocol that would be suitable for adoption and deployment in the Internet.

“bpbis”, Bundle Protocol version 7

- As in version 6 (documented in IETF experimental RFC 5050, and the basis for the CCSDS BP standard), DTN data are carried in protocol data units called “bundles”.
  - To minimize negotiation (requiring possibly lengthy round trips), the answers to anticipated requests for configuration information are proactively “bundled” in metadata accompanying application data.
- Each bundle comprises a primary block followed by N extension blocks (where N >= 0), followed by a payload block.
- All blocks are of variable length.
- A single large payload may be “fragmented” such that different parts are carried by different bundles (“fragments”).

Changes to BP in bpbis (1 of 2)

- The primary block is restructured: it remains variable-length, but now the primary block of any single bundle remains immutable from issuance to delivery. All information that may change en route is migrated into extension blocks.
- Quality of Service markings are migrated to extension blocks.
- Unique block ID numbers are added to extension blocks, enabling security blocks to target specific extension blocks.
- For any given bundle, no blocks may follow the payload block.
- Optional CRCs are added to all blocks.
- Variable-length data are encoded in Concise Binary Object Representation (CBOR).

Changes to BP in bpbis (2 of 2)

- New extension blocks:
  - Bundle age
  - Hop count (analogous to Internet packet time-to-live)
  - Previous node (i.e., the proximate sender of a received bundle)
  - Flow label (not yet defined)
  - Quality of service (not yet defined)
  - Manifest (a list of blocks that were present when the bundle was issued; not yet defined)
- “Custody transfer”, a built-in system for automatic retransmission of lost bundles, is moved to a new Bundle-in-Bundle Encapsulation protocol.

Bundle-in-Bundle Encapsulation (BIBE)

- Reliable transmission in DTN is best accomplished at the convergence layer (CL) under BP.
  - For example, BP/LTP or BP/TCP/IP.
  - End-to-end retransmission may be needed as well, in case of network failure, but for routine operations it is impractical.
- When convergence-layer acknowledgments must return over a different – possibly delay-afflicted – path from the original transmission path, BP itself is the best CL protocol.
- For this purpose, the original bundle is serialized and serves as the payload for an encapsulating bundle; acknowledgments to these bundles (“custody signals”) are likewise bundles.

Other DTN Protocols in Work

- bpsec: BP security, derived from an earlier, more complex Bundle Security Protocol specification.
  - Not a separate protocol, but rather the specifications for two additional BP extension blocks: Block Integrity Block (BIB, crypto signatures) and Block Confidentiality Block (BCB, encryption).
  - Protects data both in transit and at rest while awaiting transmission.
- tcpcl: a TCP-based convergence-layer protocol.
  - Bundles are transmitted via TCP/IP.
  - Received bundles are acknowledged, enabling reactive fragmentation.
- AMA: Asychronous Management Architecture
  - Like SNMP, but (a) implements both monitoring and reconfiguration and (b) is delay-tolerant rather than conversational.

Migration

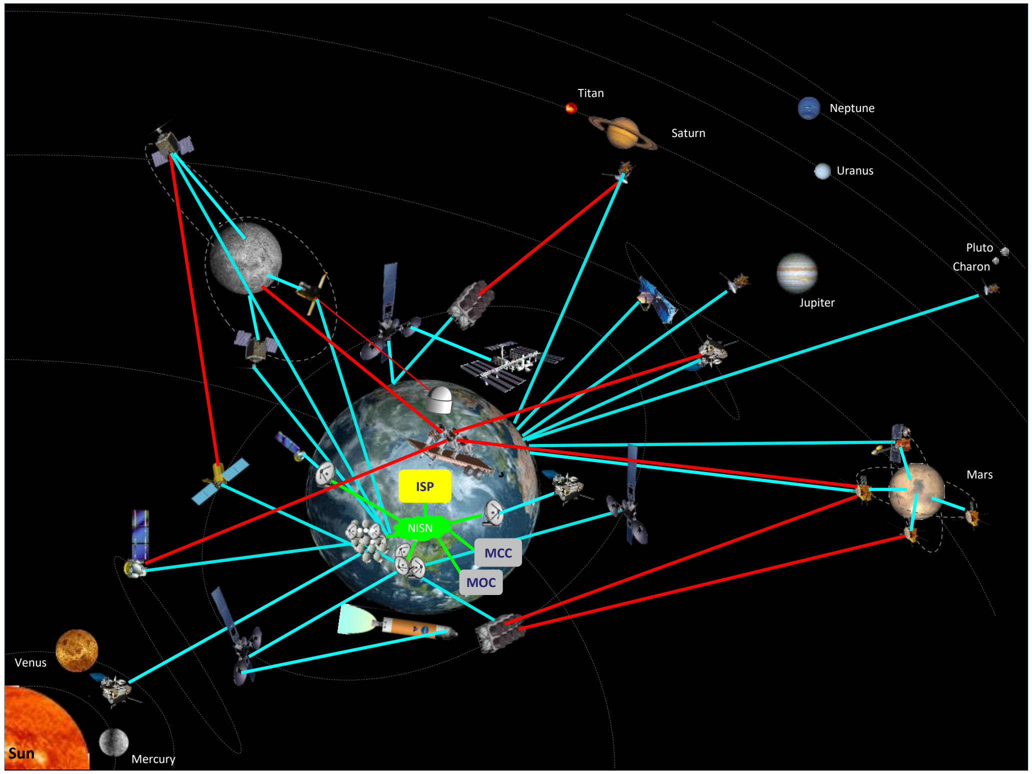
- As of IETF 100 meeting of the DTN WG (17 November 2017), the bpbis specification is being sent to the Internet Engineering Steering Group for review and (hopefully) insertion into the RFC Editor’s queue.
  - Possible issuance of a standards-track RFC in 2018.
- The resulting RFC will not be interoperable with the CCSDS BP standard, but:
  - All CCSDS BP functionality is retained in bpbis with BIBE.
  - It should be possible to develop gateway daemons that map data between the two.
- CCSDS will revise BP to conform to the new BP in a few years.
- NASA will continue using CCSDS BP as it evolves.

Future Work

- Standardization in IETF continues
  - BIBE, TCPCL, bpsec, AMA.
  - Flow label, manifest, and quality of service extension blocks.
- Other delay-tolerant protocols on the horizon
  - Multicast.
  - Delay-tolerant public key infrastructure.
    - Plus a bpsec cipher suite based on asymmetric cryptography.
  - Bundle streaming service, for streaming media over DTN.
  - Contact history exchange, for opportunistic forwarding.
  - Many more ideas in the queue.

Thanks!

Questions?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